Abstract No. arai647

Solid State Speciation of Arsenic in Poultry Litter

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Beamline(s): X26A

Introduction: In the last four decades, the poultry industry has become one of the major livestock operations in the Mid-Atlantic Coastal Plain region of the U.S. The majority of poultry litter generated during the operations has been recycled as an organic amendment on agricultural fields to meet the nutrient requirement. However, the risk assessment with respect to As contamination via poultry litter amendments has been overlooked. The origin of As in the poultry litter is an organo-arsenical compound, 3-nitro-4-hydroxyphenylarsonic acid (Roxarsone) in the poultry feed used for coccidiosis control. Approximately 25-50 mg of Roxasone / kg of feed are used and its annual total As input from Roxasone is presumed to be 1.4 X 10^4 kg. In recent years, As has become a focus of concerns in the US due to its high carcionogenicity, phytotoxicity and biotoxicity. Controversy over setting Maximum Concentration Levels of total arsenic (As) at 10 ppb in drinking water has raised serious concerns about the use of As containing biosolids (e.g., poultry litter and sludge) for agricultural/recreational uses. In this study, we investigated the As solid state speciation in poultry litter.

Methods and Materials:

Poultry litter thin sections were used for the synchrotron microfocused (μ) X-ray fluorescence (SXRF) and μ-X-ray Absorption Near Edge Structure Spectroscopic (μ-XANES) analyses. Spatially resolved surface probing spectroscopic techniques were utilized to gain a detailed knowledge of the As chemical speciation in the poultry matter. μ-SXRF analysis provides spatially resolved (≅20 μm) elemental associations of As in the poultry litter and soil samples. This surface probing technique allows one to focus on specific As hot spots, and the oxidation state and predominant solid state speciation can be determined using μ-XANES.

Results:

Arsenic was always concentrated in needle like particles (≅ 20 μm X 100 μm) in the litter materials (Fig.1). μ-SXRF analysis showed a strong As association with Cu and Ca and to a lesser extent with Fe, S and Zn (Figs.1 and 2), indicating As is possibly coprecipitaed with Ca and Cu and/or adsorbing on metal salt precipitates. Fig.3 shows μ-XANES analysis of the litter samples and reference salts and minerals. It is interesting that mixed As(III and V) oxidation states are present in the As concentrated particles A-C and a fraction of the As(III) oxidation state may be associated with a As(III)-sulfide precipitate like realgar (AsS) (Fig.3).

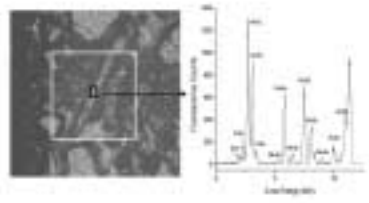

Figure-1: A photographic image of poultry litter thin section and a XRF spectrum of an As concentrated particle.

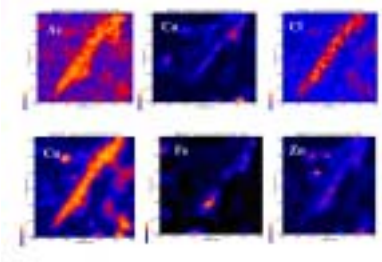

Figure-2: Elemental maps of an area (indicated by a white frame) of the photographic image in Fig-1.

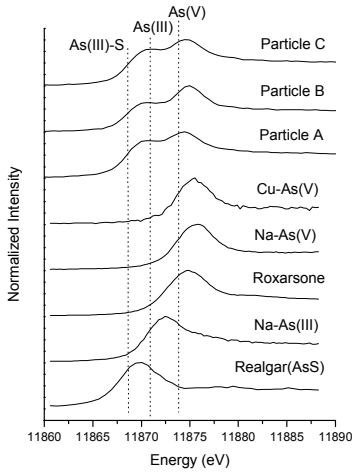

Fig.-3 Microfocused XANES spectra of As concentrated litter particles and As reference salts